

Viscosity Measurements of Propane, *n*-Butane, and *i*-Butane Between 300 and 420 K with Pressures up to 68 MPa

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Recent data analyses identified a need for additional viscosity measurements of propane and the butane isomers. Such measurements were carried out with an automated torsional crystal viscometer at sub- and supercritical temperatures between 300 and 430 K with pressures up to 68 MPa. The experimental procedure was refined with regard to the drive voltage applied to the crystal. It was observed that the magnitude of the torsional displacement of the crystal, as piezoelectrically induced by the drive voltage, influences its frequency response nonlinearly. The theoretical model for this dynamics is the generalized Duffing-Van der Pol oscillator with quadratic displacement dependences of stiffness and internal damping. Unlike the vibrating wire¹ the torsionally vibrating crystal did not exhibit a hysteresis in the drive voltage range of the present instrument. The viscosities of the hydrocarbons were deduced from vacuum and fluid measurements where the measured damping is independent of the torsional displacement of the crystal. Possible temperature gradients in the furnace and cell, which may affect near-critical measurements, were investigated by finite-element analysis. The estimated uncertainty of the measured viscosities is $\pm 2\%$. The propane results agree with a reference correlation within this margin. Systematic deviations at near-critical states are due to inadequate representations of the PVT surface in this region by the equation of state.

¹ cf. L. Aumann, A. Laesecke, R. A. Perkins, T.O.D. Lüddecke, *Characterization of a Vibrating-Wire Viscosity Sensor for Corrosive Fluids*. 14th Symposium on Thermophysical Properties, June 25-30, 2000, Boulder, Colorado, USA.